Technical Report Documentation Page

1. REPORT No.
HPR-1(4), D-0412

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
A Report on an Evaluation of Research Conducted on the Effectiveness of Headlight Glare Screen

5. REPORT DATE
June 1967

6. PERFORMING ORGANIZATION

7. AUTHOR(S)
Field, R.N. and R.A. Pelkey

8. PERFORMING ORGANIZATION REPORT No.
HPR-1(4), D-0412

9. PERFORMING ORGANIZATION NAME AND ADDRESS
State of California
Department of Public Works
Division of Highways
Materials and Research Department

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

12. SPONSORING AGENCY NAME AND ADDRESS

13. TYPE OF REPORT & PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT
An evaluation of the preliminary conducted as the initial step in an investigation of the effectiveness of headlight glare screen and the effect of median width on headlight glare is presented. The research staff conducted familiarization runs with and without a glare screen and at various lateral separations. The glare and target vehicle longitudinal relationship was also altered between runs. It was concluded that definite results regarding the discomforting and disabling effect of headlight glare could not be effectively determined by this type of investigation.

17. KEYWORDS
Glare, screens, headlight glare, evaluation, medians, widths

18. No. OF PAGES:
22

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1966-1967/67-69.pdf

20. FILE NAME
67-69.pdf

HIGHWAY RESEARCH REPORT

AN EVALUATION OF RESEARCH CONDUCTED ON THE EFFECTIVENESS OF HEADLIGHT GLARE SCREEN

67-69

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 36303

67-69

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads June, 1967

Pb-1

State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

June 1967

Laboratory Project
Auth. W. O. 36303

Mr. James E. Wilson
Traffic Engineer
California Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A REPORT ON

AN EVALUATION OF RESEARCH CONDUCTED ON

THE EFFECTIVENESS OF HEADLIGHT GLARE SCREEN

Study made by . . . . Structural Materials Section
Under general supervision of . . . . E. F. Nordlin
Work supervised by . . . . R. N. Field
Report prepared by . . . . R. A. Pelkey

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

RAP:mw

ABSTRACT

REFERENCE: Field, R. N. and R. A. Pelkey, "A Report on an Evaluation of Research Conducted on the Effectiveness of Headlight Glare Screen", State of California, Department of Public Works, Division of Highways, Materials and Research Department. Research Report HPR-1(4), D-0412, June 1967.

ABSTRACT: An evaluation of the preliminary research conducted as the initial step in an investigation of the effectiveness of headlight glare screen and the effect of median width on headlight glare is presented. The research staff conducted familiarization runs with and without a glare screen and at various lateral separations. The glare and target vehicle longitudinal relationship was also altered between runs. It was concluded that definite results regarding the discomforting and disabling effect of headlight glare could not be effectively determined by this type of investigation.

KEY WORDS: Glare, screens, headlight glare, evaluation, medians, widths.

I. INTRODUCTION

In a letter from Mr. G. A. Hill to Mr. F. E. Baxter dated January 29, 1963, it was requested that a study be implemented to determine the effectiveness of various types of headlight glare screen and to obtain factual data on the effect of median width on headlight glare. This project was subsequently approved for HPR funds and formally assigned to the Materials and Research Department as Item D-0412 in Work Program HPR-1(3), Research. A project work order, Materials and Research Department No. 63303-R, was issued July 1, 1963, "to study by means of full scale tests and jury evaluation the effectiveness of various types of headlight glare screen in increasing nighttime stopping sight distance".

At this time there were several types of glare screen under consideration and in use at field locations on a trial basis. These included shrubbery, wood and aluminum slats in the standard chain link mesh fence, and corrugated plastic panels. A related comparison study on various headlight glare screen material, Project Work Order No. 64347-R, was also being conducted[1]. Its purpose was to evaluate the effectiveness, durability, and economics of several proposed headlight glare screen materials. It was decided that before this new project could proceed, a determination should be made as to which type glare screen material was the most desirable. Therefore, this project was initially deferred pending the results of this related study.

Final results of the glare screen materials comparison study were compiled and published in a report in March 1965[1]. All seven screening materials evaluated in this study were effective in reducing headlight glare to some extent when properly installed. However, all except the expanded aluminum exhibited serious weathering defects. These weathering defects in some cases, such as with flexible webbing, decreased the glare reducing effectiveness. With other materials, such as the rigid slats, the effectiveness was decreased because of the flicker caused by the headlight beam as it passed between them. Although these vertical slats reduced headlight glare, the flicker produced an objectionable distracting effect on the driver. Of all materials tested the prepainted expanded aluminum sheet appeared to be the most desirable material.

An initial proposal made at this time included an evaluation of the 1" and 2" mesh chain link fence in addition to the expanded aluminum. It was felt that this material, not previously investigated, might prove to be an efficient screen in reducing low angle headlight glare. The Traffic Department reported that "although the standard 2" chain link mesh presently used on cable barriers is not a positive headlight glare shield, it does substantially reduce the intensity of this glare". A report from the State of Texas presented at the 1963 Highway

Research Board meeting in Washington stated that "1 in. chain link mesh was very successful as a headlight glare screen . . ." A preliminary laboratory evaluation of the light passing properties of expanded aluminum and several chain link mesh materials was conducted. Table I lists the percent of light transmission at various incidence angles.

TABLE I

GLARE SCREEN

TRANSMISSION OF LIGHT

Type of Glare Screen	Angle 5°	10°	15°	30°	45°	90°
Expanded Metal (Aluminum) (1.33 x 4 Diamond)	0	0	0	11	40	74
One Inch Chain Link Mesh (Steel 11 ga.)	7	15	25	65	77	80
One Inch Chain Link Mesh (Steel 9 ga.)	5	10	19	48	70	79
Two Inch Chain Link Mesh (Steel 9 ga.)	27	52	63	79	85	88

PERCENT TRANSMITTANCE

It is apparent from the light transmission tests tabulated above that the expanded mesh transmitted the least amount of light at the critical viewing angles of less than 30 degrees with an actual cut-off angle of between 15° - 20°. At angles between 20° and 90° the intensity of the transmitted light increases smoothly and proportionately with the viewing angle. There is no sudden change in intensity as the angle varies as with the chain link materials. At angles approaching 90 degrees, vision through the barrier is virtually unobstructed which makes travel more pleasant for the motorist. This "see through" characteristic is also of value to the highway patrol in observing traffic conditions.

Test parameters based on this laboratory evaluation and upon factors observed in the aforementioned comparison study were established for a preliminary glare investigation to be performed at the Lincoln Airport Test Facility. The initial investigation was primarily to additionally familiarize the research staff with the problems of headlight glare and provide an insight into the difficulties which might be encountered in performing a subsequent full scale jury evaluation program.

This report summarizes the results obtained from the preliminary investigations and from an evaluation of data obtained from other researchers.

This work was accomplished in cooperation with the United States Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

II. OBJECTIVE

The primary objective of this study was to determine the effect median width had on the disabling effect of headlight glare. Secondary objectives were as follows:

1. To determine the effect of glare discomfort.

2. To evaluate the effectiveness of the expanded metal glare screen.

3. To examine the effectiveness of various size chain link mesh as a glare screen material.

III. CONCLUSIONS

As the primary objective of the initial investigation was to determine test parameters and methods of measurement, no attempt was made to obtain an actual evaluation of glare screen requirements during this stage of the study. The preliminary test runs prior to installing glare screen indicated that although target identification distance varied considerably between observers, there was some degree of correlation with the data obtained by Idaho[4] on the glare disability portion of their study. However, it immediately became apparent that there were many variables both in the geometric layout of the test site as well as in the complex physical problems involved in making objective glare evaluations.

Other researchers have found that when attempting to make an objective measurement of the effect of headlight glare there are variables more complex than visual acuity, such as threshold level, veiling brightness, and related psycological and physiological factors[3].

The importance of the effect glare discomfort may have on the driver rather than actual glare disability should not be overlooked. The distraction of a driver from the primary visual task of driving in an attempt to avoid the discomforting effects of glare is not uncommon. The resultant lack of awareness of the movement of surrounding traffic produces a potentially hazardous situation. In addition, the constant change from a glare to no-glare condition, even below the discomfort level, can produce a physical fatigue resulting in slower driver response as well as traffic inattention.

It is felt that the results obtainable from any study of this nature are of questionable value. When using target detection distance as a measure of visibility, the measurements would represent the maximum sight distance, because they would be obtained under ideal conditions. In other words, the observer would be concentrating on detecting a known target at a known location, and would not permit glare discomfort to distract him from this goal. Also, glare conditions produced in a controlled test would not always be representative of actual operating conditions on the freeways. Each test run would produce results applicable only to the geometry and glare condition employed.

Because of (1) limited research manpower, (2) the informative results obtained from the earlier Marin County field comparison study, and (3) the additional feel for the problem gained from this preliminary investigation, it was concluded that no further research into the headlight glare screen problem should be performed to permit the equivalent research effort to be directed into other traffic safety problems currently more critical to the California Division of Highways.

IV. DISCUSSION

A. TEST SITE

The test site for this investigation was a closed runway of the Lincoln Airport. The runway is approximately 300 ft. wide and 4,000 ft. long and is paved with a nonreflective bituminous mix surfacing. The surrounding area is flat with short weed stubble type vegetation (Figure 1).

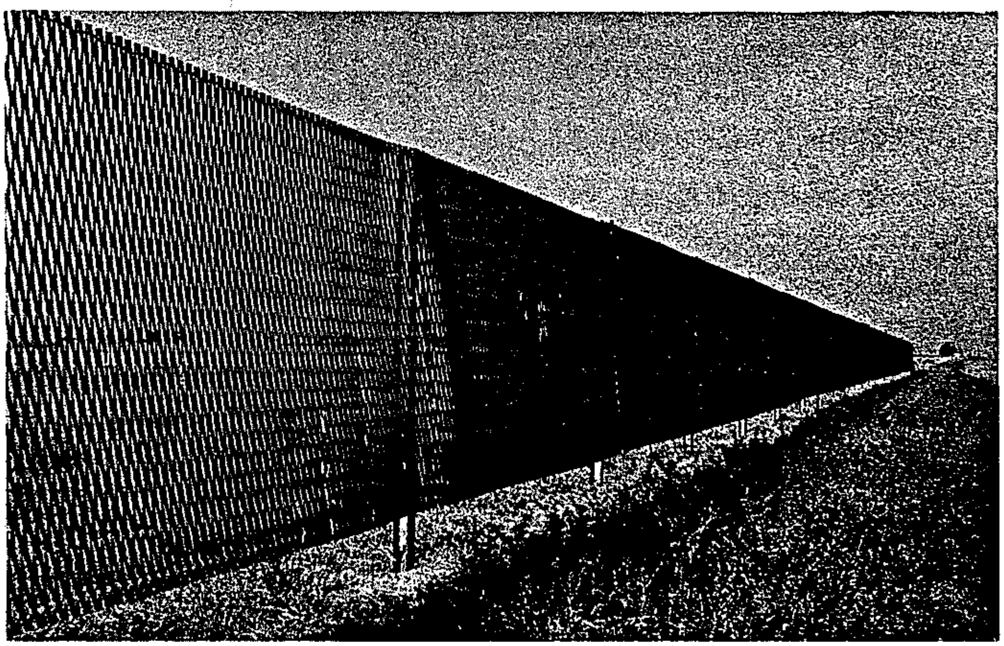


Figure 1

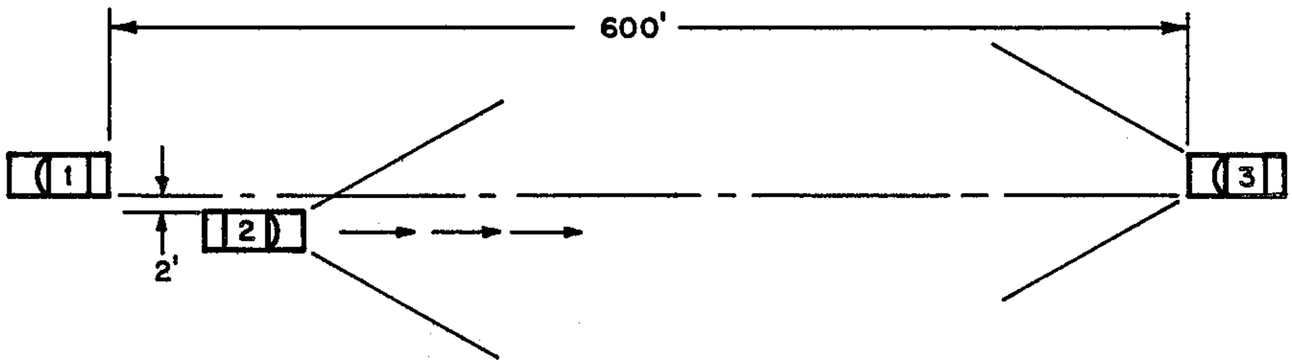
There are no extraneous light close enough to the test site to significantly alter the ambient light level which was at a low and constant level. Along one edge of the runway, 4 ft. off the edge of the paved surface, a 450 ft. section of expanded metal glare screen was constructed (Exhibit 1).

Simulated traffic lanes running parallel to the glare screen were delineated on the paved surface of the runway. The lanes were spaced to simulate median widths of 12, 22, 36, 46, and 60 feet. This was accomplished by assuming that the opposing vehicles would be traveling 2 ft. from the left-hand edge of their respective traveled lane. By spacing the vehicles at lateral separations of 16, 26, etc. feet, the desired median width was attained. Tests conducted on this flat plane simulated the glare condition of approaching an opposing glare vehicle on a constant grade, tangent section of highway (Exhibit 2).

B. PILOT STUDY

An initial check of the test site layout and a pilot study was conducted on a clear night in early March 1965. The investigating team consisted of Mr. J. R. Stoker and Mr. R. N. Field of the Materials and Research Department, Mr. T. N. Tamburri of the Traffic Department, and Mr. David Solomon of the Bureau of Public Roads.

It had been suggested earlier that, to simulate the most critical glare condition, the glare producing vehicle with the headlights on high beam should approach the observers' vehicle "head-on". This pilot study was conducted using these test parameters. Late model standard size sedans were used in this study. An unlighted target vehicle was positioned in one of the simulated traffic lanes. The observer vehicle with its headlights in the low beam mode was positioned 600 feet away, longitudinally on line and directly behind the target vehicle. With these vehicles stationary, the glare vehicle with headlights in the high beam mode approached the observer vehicle. The glare vehicle's line of travel was offset 2 feet laterally to the left of the observer vehicle, primarily to provide clearance for and prevent displacement of the target vehicle (Figure 2).



1. STATIONARY TARGET VEHICLE
2. MOVING GLARE VEHICLE
3. STATIONARY OBSERVER VEHICLE

Figure 2

The observers, two in the front seat of the observer vehicle, viewed the rear of the unlighted target vehicle as the glare vehicle moved towards them at approximately 30 mph. The observers were to indicate when the target vehicle fell below threshold level.

Although the glare producing vehicle was in the center of the visual field and the intense portion of the opposing headlight beam was directed at the eyes of the observers, the reflective portion of the tail light on the target vehicle was detectable for the entire run by all of the observers. This, it was later concluded, was due to three factors. First, the observers' eyes were subjected to a gradually increasing glare intensity as the glare producing vehicle moved towards the observer vehicle. The eyes were thus able to adjust to the increasing illumination level. Second, the observers could easily detect the target vehicle at the initial or low glare condition. As the glare intensity increased, the observers could fixate on the target and keep it in view under a much higher glare condition than would have been possible were the target to have been initially below threshold level and then suddenly become detectable. Third, the observers sitting in a stationary vehicle had no visual distractions from viewing the target as would be encountered in normal highway driving. Thus, their undivided attention could be directed towards the target vehicle.

From this pilot study it was determined that further research should be conducted with the glare and target vehicles stationary and the observer vehicle moving. Using this set-up, any particular glare condition could be created by proper placement of the glare and target vehicles. Detection distances could be measured as the observer vehicle moved towards the target vehicle. It was felt that as the observer vehicle approached the target vehicle, the glare intensity would drop to the point where the target vehicle would be above threshold level and become visible. This it was felt would also be more representative of the actual dangerous condition experienced on a freeway where an opposing vehicle's headlight glare interferes with a driver's vision when coming up behind a stalled or slower moving vehicle.

It was also decided that several different relative distances between the glare and target vehicles be used, with the stationary target vehicle both ahead of and beyond the glare vehicle. This would impose different glare conditions upon the observers which could directly affect their detection ability. By varying the distance of the glare vehicle ahead of the target vehicle, the adaption time from a glare to a no-glare condition is also varied. By varying the distance of the glare vehicle beyond the target vehicle, the target vehicle could be anywhere from within the area of highest glare intensity to being silhouetted by the glare vehicle. Varying the lateral separations of the glare and target vehicles was also a criteria that affects target detection. An increase in lateral separation between glare and observer vehicles results in the opposing headlights being at a greater angle from the observers' line of sight, producing both lower glare intensity to the observers as well as less illumination and background contrast to the target vehicle.

All of these conclusions were included in the recommendations for conducting a full scale jury evaluation. However, prior to conducting the actual study, it was felt that the research team that was to direct the operation should further familiarize themselves with the problems of headlight glare.

C. PRELIMINARY INVESTIGATION

On a clear night in late March 1965, the preliminary investigation was performed. The initial runs conducted at this time were at various lateral separations without a glare screen. This was to establish a basis of evaluation of the glare reducing effectiveness of the expanded metal glare screen.

The vehicles employed were retired highway patrol cars. These 1963 Dodge sedans have standard dual headlamp units. Prior to the investigation the headlamps were checked for illumination level and alignment. The target vehicle used was a 1962 Dodge Dart.

For the first series of runs, both the glare and target vehicles were stationary, longitudinally opposite each other at an initial lateral separation of 16 feet. With the headlights of the glare vehicle in the high beam mode, the observer vehicle with its headlights in the low beam mode was driven toward the rear of the unlighted target vehicle at a speed of 30 mph. The driver of the observer vehicle was directed to indicate to the passenger/recorder when he initially experienced glare discomfort and when he first detected any portion of the target vehicle. The runs started with the observer vehicle up to 2,000 ft. behind the target vehicle. The glare effect was negligible at this distance. However, as the observer-to-target distance closed, the observers were subjected to a change from the initial no-glare condition to glare discomfort, then glare disability and then back to a glare discomfort and no-glare condition. The ability of the observers to react and adapt to these changes in illumination level varied considerably between subjects. The target detection distances varied relative to the glare adaption capability of the subject. Glare discomfort on the other hand proved to be elusive of measurement. There appeared to be no direct correlation between visual and discomfort sensitivity to glare. It was felt that a more relative comparison might be possible from the results obtained from a full scale jury evaluation study. With the wider range of visual acuity from the larger number of subjects available, it was hoped a trend or logical pattern might become apparent. Additional runs were made alternating the researchers as driver/observer and passenger/recorder to familiarize all personnel with all phases of the test procedure. Subsequent runs were also conducted varying the lateral and longitudinal relationship of the target and glare vehicles.

Because the primary objective of this preliminary investigation was familiarization, little data were compiled or recorded. A check was made at the initial 16 foot lateral separation to insure the correctness of the test procedure. At this separation width, an average target identification distance of approximately 260 feet was established. This compared favorably with the Idaho Department of Highways Test[4] which determined an average sight distance of 262 feet for a 22 foot lateral separation.

This sight distance was established by Idaho following a test procedure similar to that used for our study. However, in the Idaho investigation, both the glare and observer vehicles operated with headlights in the high beam mode and the target used was a wood "A" frame structure 24" high.

Further runs were also conducted following the same test procedure; however, the glare and target vehicles were positioned on opposite sides of the expanded metal glare screen. The purpose was to establish a test criteria for use when conducting the full scale jury evaluation of the effectiveness of various glare screens. Results from these runs indicated that opposing headlights may be detected through the glare screen when the angle between the observer and the glare vehicle approaches 18° from the direction of travel. This corresponds with our laboratory tests which indicated a cut-off angle of between 15° - 20° for this material, with only 11% passing at 30°.

At an 18° viewing angle without benefit of a glare screen, glare was not considered objectionable and did not interfere with vision. At viewing angles less than 18° where glare would be approaching the discomfort level, the expanded mesh passes no light and would be considered opaque. At viewing angles greater than 30° where the percent of light passing through the expanded mesh is noticeably increased, glare is not detrimental.

As a result of these initial tests a new project proposal was prepared. This proposal stated that in order to effectively evaluate headlight glare disability and discomfort and to obtain specific data on median width vs. headlight glare, it would be necessary to perform additional tests using a jury evaluation method. It also stated that it would be desirable to investigate such variables as the light scattering effects of moisture and/or dirt on windshields, different types of targets, various combinations, and numbers of glare producing vehicles and randam lateral and longitudinal positioning of the glare vehicle and targets. At the time that this proposal and the exact method of handling the jury portion of the investigation was being studied, a number of new studies relating to traffic safety which urgently required investigation were in progress. The unit's research staff was fully occupied and postponement of these new projects to reactivate the glare screen study did not seem justified. In addition, considerable research had been conducted on this subject by others since the inception of the California study in 1963. The results of other researchers' studies supplemented by an evaluation of our initial investigation plus the operational experience we had obtained from the experimental installation on U. S. 101 and on our new freeways, led to the adoption of the expanded metal glare screen as a standard design for glare protection to be used on all new median barrier installations. In view of California's policy to include expanded metal glare screen on all median barriers and also at other locations where critical glare problems exist, no further research is proposed on this project.

IV. REFERENCES

1. Doty, R. N. and Ledbetter, C. R., "An Experimental Glare Screen Installation on U. S. 101 - IV-Mrn-1-C, Between Tamalpais Road and Corte Madera Creek", California Division of Highways, March 1965.

2. Roth, W. J. and Youngblood, W. P., "Anti-Glare Screen Study", State of Michigan, March 1966.

3. Powers, L. D. and Solomon, D., "Headlight Glare and Median Width - Three Exploratory Studies", July 1965.

4. Fries, J. R. and Ross, L. J., "Headlight Glare vs. Median Width", Idaho Department of Highways.

5. Hofer, R., Jr., "Glare Screen for Divided Highways", Aluminum Company of America, 1962.

6. Jehu, V. J. and Gregsten, M. J., "Headlight Glare Screens on Motorways", Traffic and Safety Division, Great Britain, September 1959.

7. Jehu, V. J., "A Comparison of American and European Headlight Beams for Vehicles Meeting on a Straight Road", Traffic and Safety Division, Great Britain, April 1954.

8. Blackwell, H. R. and Pritchard, B. S., "Illumination Variables in Visual Task of Driver", Ohio State University, U. S. Bureau of Public Roads, R. N. Schwab, December 1965.

9. Wolf, E., "Glare Sensitivity in Relation to Age", Retina Foundation, Boston, Massachusetts.

10. Boone, E. P., "Automobile Glare and Highway Visibility Measurements", Corps of Engineers, Department of the Army, March 1951.

11. Hoppe, D. A. and Lauer, A. R., "Factors Affecting the Perception of Relative Motion and Distance Between Vehicles at Night", Iowa State College, November 1951.

12. Peckham, R. H., "Effect of Exposure to Sunlight on Night Driving Visibility", Temple University School of Medicine, June 1952.

13. Stalder, H. I. and Lauer, A. R., "Effect of Pattern Distribution of Perception of Relative Motion in Low Levels of Illumination", Iowa State College, January 1952.

14. Richards, O. W., "Vision at Levels of Night Road Illumination", American Optical Company, Research Laboratory, January 1952.

15. Blythe, J. D., "Highway Lighting and Accidents in Indiana", Indianapolis Power and Light Company, January 1956.

16. Wyatt, F. D. and Lozano, E., "Effect of Street Lighting on Night Traffic Accident Rate", January 1956.

17. Rex, C. H., "Principles and Figures of Merit for Roadway Lighting as an Aid to Night Motor Vehicle Transportation", General Electric Company, January 1956.

18. Feldhaus, J. L., "Dynamic Visual Acuity Effect on Night Driving and Highway Accidents", January 1961.

19. Domey, R. G. and McFarland, R. A., "Dark Adaptation Threshold, Rate, and Individual Prediction", Harvard School of Public Health, January 1961.

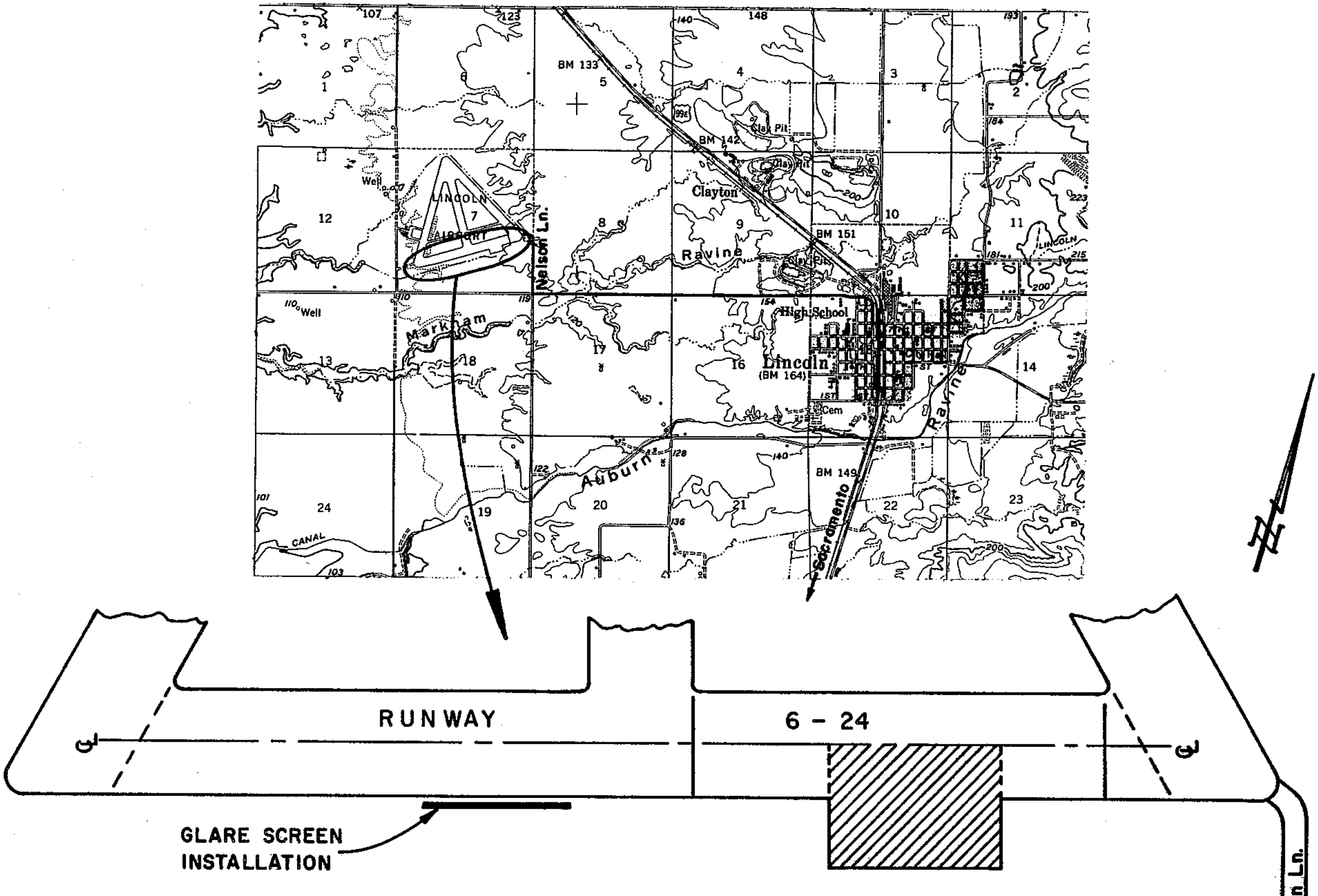
20. de Boer, J. B., "Road Surface Luminance and Glare Limitation in Highway Lighting", N. V. Philips' Gloeilampenfabrieken, Eindhoven Netherlands, January 1961.

21. Domey, R. G., "Flicker Fusion, Dark Adaption and Age as Predictors of Night Vision", Harvard School of Public Health, January 1962.

22. Huber, M. J., "Traffic Operations and Driver Performance as Related to Various Conditions of Nighttime Visibility", Yale University, Bureau of Traffic Safety, January 1962.

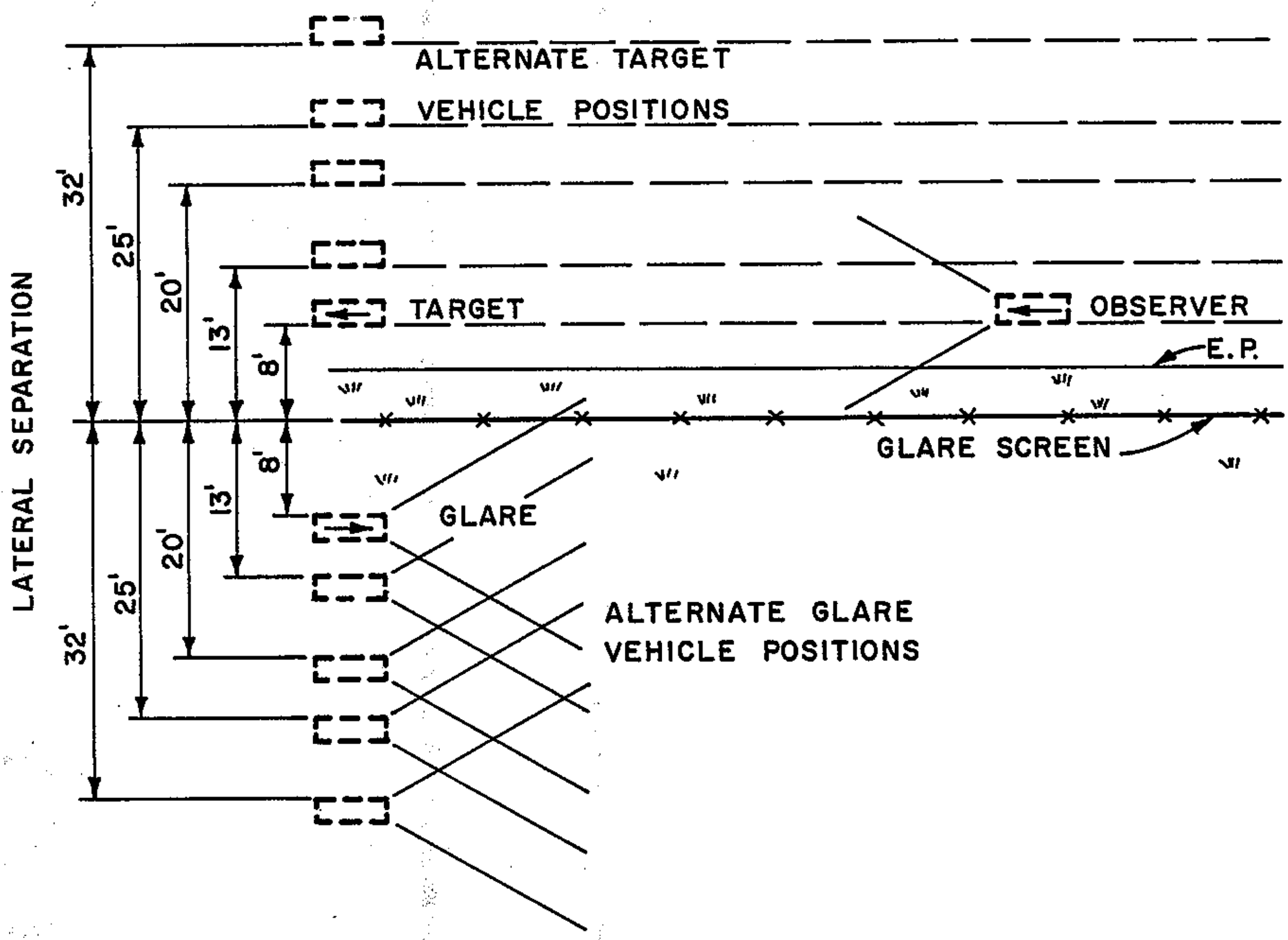
23. Rex, C. H., "Visual Data on Roadway Lighting", General Electric Company, January 1962.

EXHIBIT 1



LINCOLN AIRPORT TEST SITE

EXHIBIT 2



TEST SITE LAYOUT